Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE EFFECT OF DEFORESTATION IN THE SIHASTRIA WATERSHED, SUCEAVA COUNTY, ON THE TECHNICAL EFFICIENCY OF THE SMALL HYDROELECTRIC POWER PLANT

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Abstract

This paper aims to identify deforested surfaces in the studied area, fact that determines the intensification of soil erosion process and furthermore it increases the alluvial effluent witch disrupts the functioning of the hydroelectric power plant in the projected parameters. In 1990 the area covered with forest vegetation in the Sihastria watershed was about 147 ha, but due to the clear-cut on the areas that were returned to the right owners, the wooded area was reduced to 100 ha, from which, as a result of excessive cuts on 39 ha the density of the trees is very low. The Sihastria small hydroelectric power plant is located at the confluence of the Sihastria stream with Negrisoara River (25.525309^0 eastern longitude and 47.1917847^0 northern latitude). The hydropower plant constructive elements consist of: intake, desilting tank, fore bay tank, penstock pipe, and power house and tailrace channel. In order to determine the causes that led to the clogging of hydrotechnical constructions, trips were carried out in the analyzed watershed, during the vegetation seasons of the last three years (2015-2017).

***Key words**: deforestation, soil erosion, alluvial, unclogging, electricity.*

INTRODUCTION

In many parts of the world the management of soil and water resources represents an important issue. The pressures exerted by the anthropic factor on the environment are reflected in its quality, but also in the quality of life in general (Bucur, 2016; Zelenakova, 2018; Pierre R., 2018).

In Romania, the surface covered with woody vegetation decreased considerably in the 20th century. If in the year of 1880 the total forest surface of the country was approximately 40%, in present the forestry fund represents only 26.39% of the total country surface (Romsilva, 2016).

In Romania, the amount of water lost due to water erosion is 2.86 t/ha, and in Suceava County this quantity is approximately 2.59 t/ha. (EUROSTAT).

Among renewable energy sources, hydropower and the potential for its exploitation by constructing hydropower plants have a very important place (Milena, 2013). The analyzed river reservoir is located in the north-western part of the Bistrita River, reservoir belonging to the Brosteni Municipality from Suceava County. From a physico-geographical point of view, the hydrographical reservoir belongs to the Bistricioarei Mountains from the Moldavian-Transylvanian Carpathian sub-region, situated between Calimanilor Massif, Binaru Massif and the Grintisul Mic Massif. Regarding geology, the analyzed reservoir is composed of crystalline dolomite and epimetamorphic shale of the sedimentogenic volcanogenic series.

In the studied area, the dominant soil classes are cambisols, spodosols and cernisoils. The identified soil types are: districambosoils - predominant throughout the entire surface of the reservoir; prepodsoils - present on the valley of the Sihastria stream, and redzinas - identified in the upper part of the hydrographic reservoir.

MATERIALS AND METHODS

In order to determine the causes that led to the clogging of the hydro technical constructions, observations were made regarding the condition of wood vegetation on the slopes and on the behavior in exploitation of the constructive elements of the hydrotechnical arrangement under study.

The observations were carried out during the vegetation seasons of the last three years (2015-2017).

For the quantitative estimation of erosion, it has been used the universal soil erosion formula, adapted for Romania by Motoc M., after Wischmeyer, 1960.

$E=K\times S\times C\times C_s\times L^{0.3}\times(1.36+0.97\times i+0.138\cdot i^2)$, $(t\cdot ha^{-1}\cdot y^{-1})$

where:
K - the rainfall erosivity index
S - soil erodibility coefficient;
C - the plant cover factor;
C_s - specific erosion control practices coefficient;
L - length of slopes;
i - slope land.

In order to determine the morphometric elements of the hydrographic reservoir, were used maps made with the help of Geographic International Systems (GIS), drawn at 1:25.000 scale.

RESULTS AND DISCUSSIONS

The Sihastria stream, one of the main tributaries of the Negrisoara River from the left side, springs from the Calimanel Massif at a height of 1565 m and it has a total length of 8.5 km.
Morphometric indicators of Sihastria hydrographic reservoir are:

- catchment length C = 33.4 km,
- watershed surface F = 22.26 km^2;
- length of watershed L = 14 km;
- average width of watershed B = 1.6 km;
- sinuosity coefficient S_t = 1.56;
- density of the hydrographical network D = 0.96 km^{-1}.

The amount of rainfall recorded in the period of 2009-2013 it was about 819.24 mm period at the nearest meteorological station and the average temperatures recorded in the same period of time were 5.76°C (Table 1).

Table 1. Monthly average of rainfall (mm) and air temperatures (°C) recorded at Poiana Stampei in period 2009-2013 (National Meteorological Administration)

Month	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*Total/Average*
Rainfall	36.37	35.32	44.5	69.74	126.68	143.75	114.96	72.68	59.28	36.16	34.9	44.9	819.24
Temp	-5.69	-5.08	-1.13	6.27	11.8	15.44	16.89	16.71	11.29	5.16	1.78	-4.15	5.76

The surface of the hydrographic reservoir is 2223 ha. In 1990 the surface of the reservoir was covered with woody vegetation in proportion of 66.39% (1,476 ha).
At present, the situation of forest land has changed considerably due to uncontrolled deforestation which happened with the issuing of law 18 of 19.02.1991, relating to the reconstitution of the property right.
The largest quantities of wood have been deforested from 2005 to 2012. In 2017 the situation of forests is presented as follows:

- 451 ha have been clear-cut deforested;
- On 442 ha have been executed deforestations (approximately 60% of the area);
- 583 ha suffered a limited intervention of the anthropic factor.

For determination of soil erosion three maps were made to highlight the slopes, depth of valleys and length of the slopes.
After analysis of the slopes map (Figure 1) was found that most significant slopes vary from 10^o to 30^o, which represents approximately 68% of the surface of the reservoir.

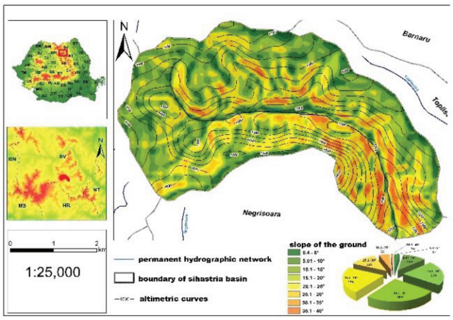

Figure 1. The slopes map

To emphasize torrential activity was developed a map to highlight the depth of the valleys (Figure 2), the highest values being recorded in the southern part of the reservoir and at the confluence of Sihastria stream with Negrisoara stream, values between 400-472 m/km^2.

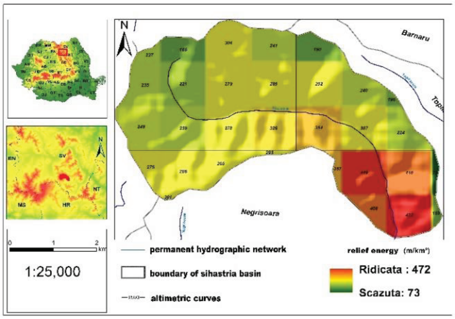

Figure 2. Depth of the valleys map

The length of the slopes varies significantly, from the lengths of 100 m to 800 m, the most significant slopes ranging from 200-300 m (Figure 3).

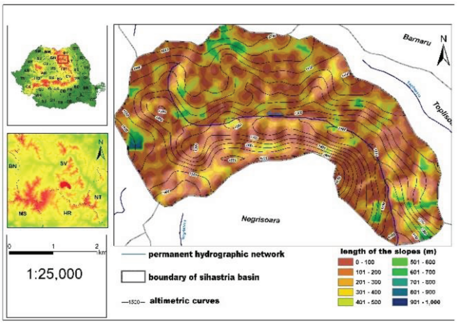

Figure 3. Length of the slopes map

After analyzing the topographic maps of geodeclivity and the average length of the slopes, quantitative estimation of soil erosion was possible, based on the universal calculation formula developed and adapted for Romania by Motoc M., after Wischmayer.

Table 2. Quantitative Estimation of Soil Erosion in the Sihastria river reservoir

Slope land I (%)	Eroded soil ($t \cdot ha^{-1} \cdot year^{-1}$) on:		
	Well-covered meadows	**Moderately-covered meadows**	**Forest on degraded lands**
< 10	0.21	1.06	0.95
10-15	0.541	2.137	1.814
15-20	0.799	5.049	4.246
20-25	1.367	8.203	6.988
25-30	2.125	12.863	10.962
> 30	3.093	18.868	16.084
18.5*	**1.06***	**6.16***	**5.24***

* - weighted average values

These data confirm that on land areas with moderately-covered meadows, but also in places where deforestation has led to soil degradation, no matter if some areas remained wooded, the average amount of soil lost was 8.203 t/ha/year on meadows and 6.988 t/ha/year on degraded lands with slope ≥ 20%, covered with woody vegetation.

The primary functionality of SHPs is the transformation of the river's water energy into electrical energy (Luka, 2015; Lehner, 2005). SPH Sihastria produces an average of 2.77 MWh per day, and the months with the highest amount of energy produced are May, June and July. The amount of electricity produced in 2017 is presented in table 3.

Table 3. Amount of energy produced at SHP Sihastria in 2017

Month	MWh	MWh/day	MWh/month
January	0.1	2.4	74.4
February	0.1	2.4	60
March	0.09	2.37	73.5
April	0.1	2.48	74.4
May	0.19	4.61	143.1
June	0.16	4.02	120.8
July	0.12	3	93.1
August	0.1	2.4	74.4
September	0.1	2.4	72
October	0.1	2.4	74.4
November	0.1	2.4	60
December	0.1	2.37	73.5
Average	**0.11**	**2.77**	**82.8**

Observations have been made during field trips regarding the state of woody vegetation and the causes of clogging of the construction elements.

Figure 4. Clogged forebay tank

Further analysis of field observations highlighted the consequences of clogging on the electricity production process, as follows:

- The forebay tank (Figure 4) must be unclogged at least once a year, the cost of this unclogging process is between 4000 - 6000 euros, during which the power plant is decommissioned for up to 7 days, which leads to an average loss of 19.93 MWh;

- Water capture zone (Figures 5 and 6) located on the stream bed is clogged about 3 times a year, the cost of its unclogging ranging from 250 - 500 euros depending on the mass of clogging, the unclogging process takes between 8-12 hours and leads to a loss of 3.3 MWh per year.

Figure 5. Clogged intake

Figure 6. Clogged intake

- The absence of anti-erosion measures on the slopes increases the erosion process, large amounts of plant residue reaching the stream bed.
- Because of the large amount of solid suspensions in the water used to produce electricity, as well as repeated unclogging made in the compensating reservoir, respectively capture zone, the degree of wear of the hydrotechnical construction and technical equipment (lines, turbines) has increased significantly.

CONCLUSIONS

The forested area within the reservoir has decreased considerable, at present about 20% of it is totally cleared up, which determines the manifestation of soil erosion on the slopes.
The main cause of clogging is uncontrolled deforestation that favors increased soil erosion.
The forebay tank (Figure 3) must be unclogged at least once a year; the cost of this unclogging process is about 5,000 euros. For 7 days the power plant is switched off, with an energy loss of about 20 MWh.

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